Value Aided Satellite Altimetry Data for Weapon Presets

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Collaborators: Gene Bessacini, Dave Cwalina (NUWC)

Purpose

- To define Navy altimeter requirements as a minimum number of satellite altimeters necessary to ensure maximum weapon effectiveness

- To determine the point at which additional altimeter input no longer increases weapon effectiveness

Objectives

- Investigate the effects of satellite altimetry data vs. climatology data on weapon preset effectiveness

- Define a metric for comparing MODAS data and GDEM data to initialize presets

GDEM

- Generalized Digital Environmental Model
- Created using Temperature and Salinity profiles.
  - Master Oceanographic Observation Data Set (MOODS)
- Climatology
- 1/2 Degree Resolution

MODAS

- Modular Ocean Data Assimilation System
- 100 Separate programs
- Dynamic Climatology
- Relocatable Princeton Ocean Model
- SSH and SST from satellite altimeters
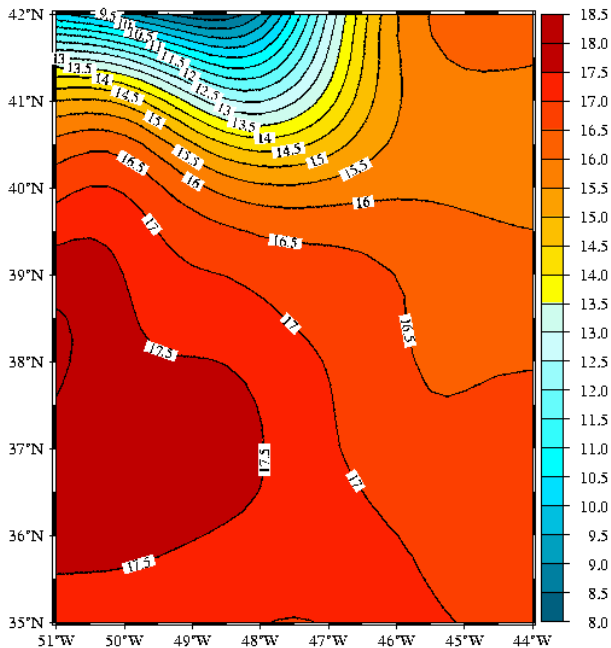- 1/8 Degree Resolution

MODAS

6-Aug-1995

200 m temperature Climatology

MODAS including MCSST does not significantly alter climatology

SSH reveals concealed ocean environment

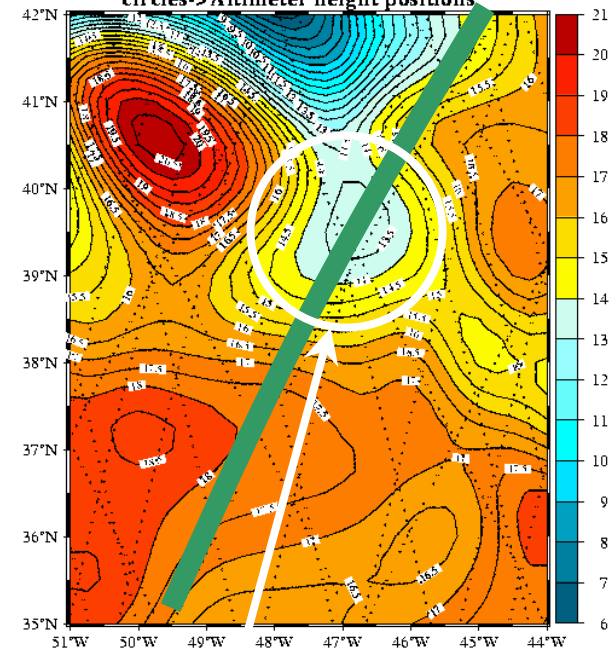Climatological Temperature (Degs C)
200 m 1995/08/06

Temperature (Degs C) from OI Analysis
0 m 1995/08/06
squares->AXBTs circles->MCSSTs
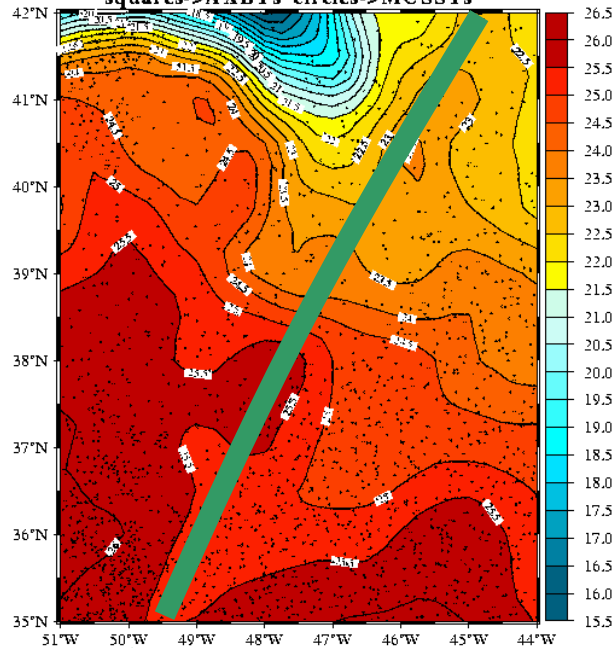
Climatological+SSH Temperature (Degs C)
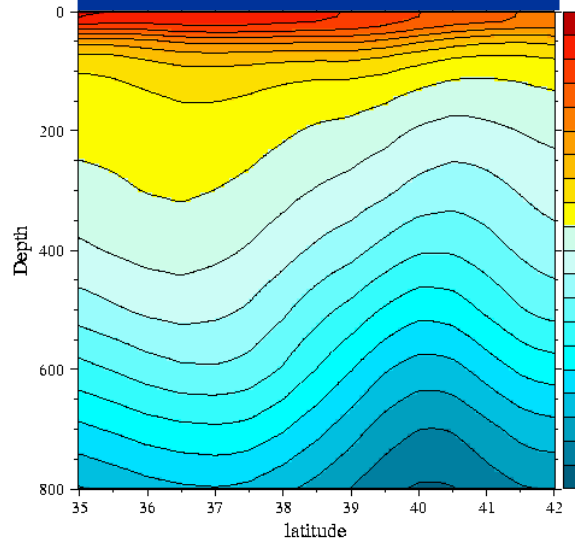200 m 1995/08/06
circles->Altimeter height positions
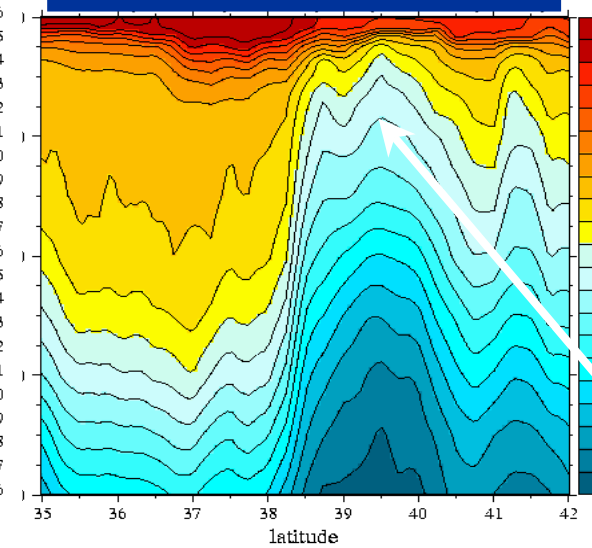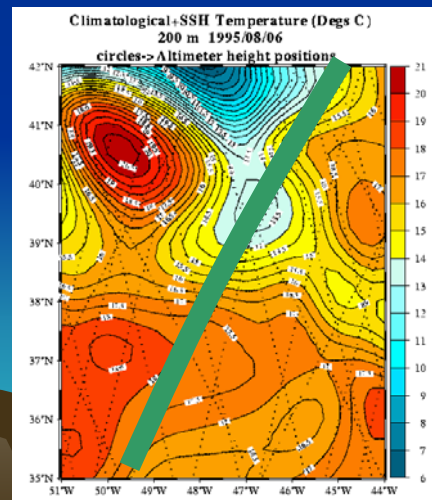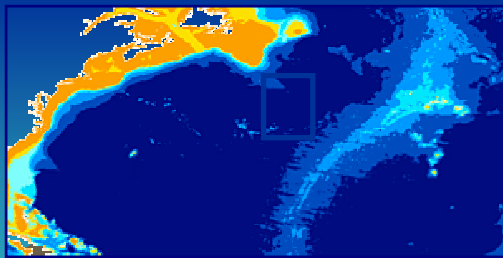
AXBT Line

Points: MCSST

Cold core eddy

MODAS

Climatological Temp

AXBT Temp

SSH + SST + Clim

Climatological+SSH Temperature (Degs C)
200 m 1995/08/06
circles->Altimeter height positions
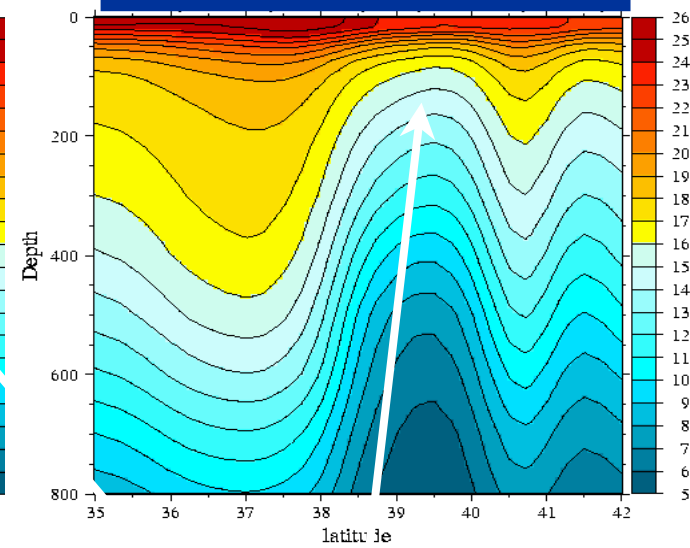
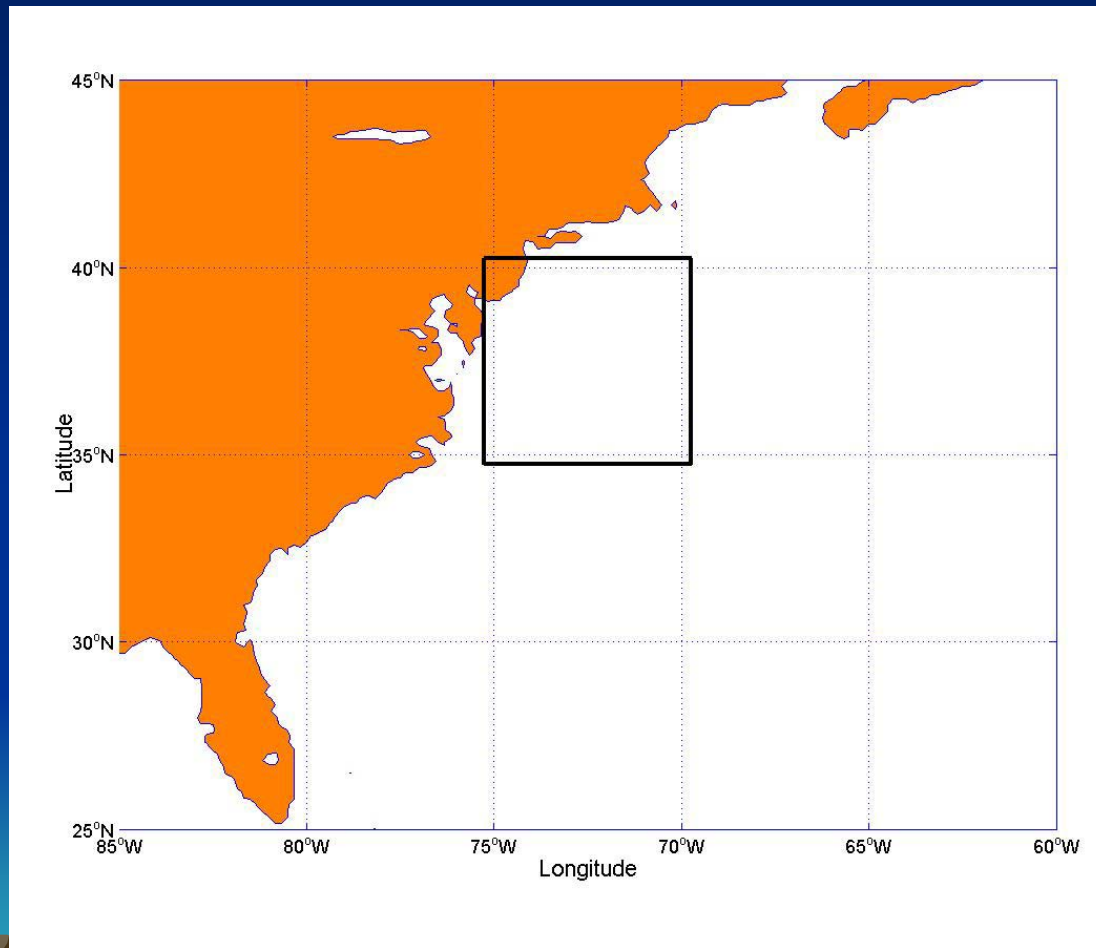**Cold core eddy**

MODAS Temperature at 200m

Data Sets

- GDEM Profiles
  - March 15, 2001
  - 117 profiles
  - 35.0N-40.0N
  - 75.0W-70.0W

- MODAS Profiles
  - March 15, 2001
  - 1633 profiles
  - 35.0N-40.0N
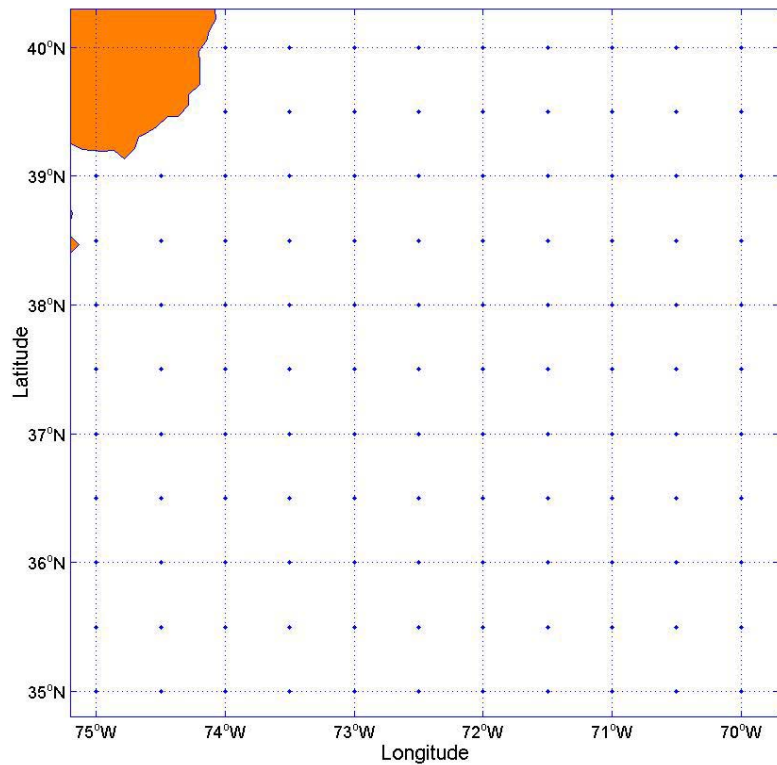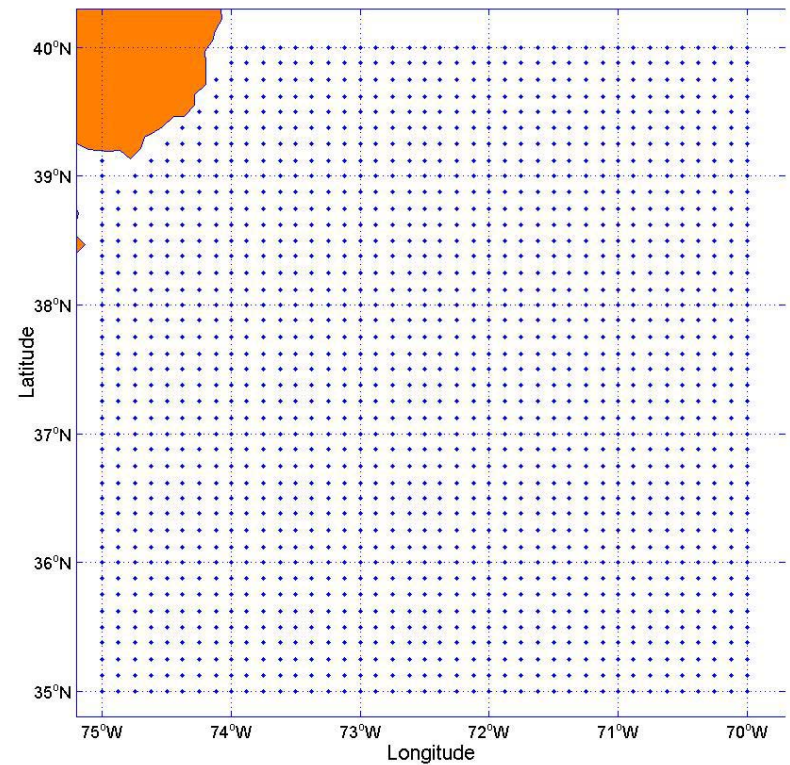 - 75.0W-70.0W
  - 4 altimeters

Area of Investigation

Data Points

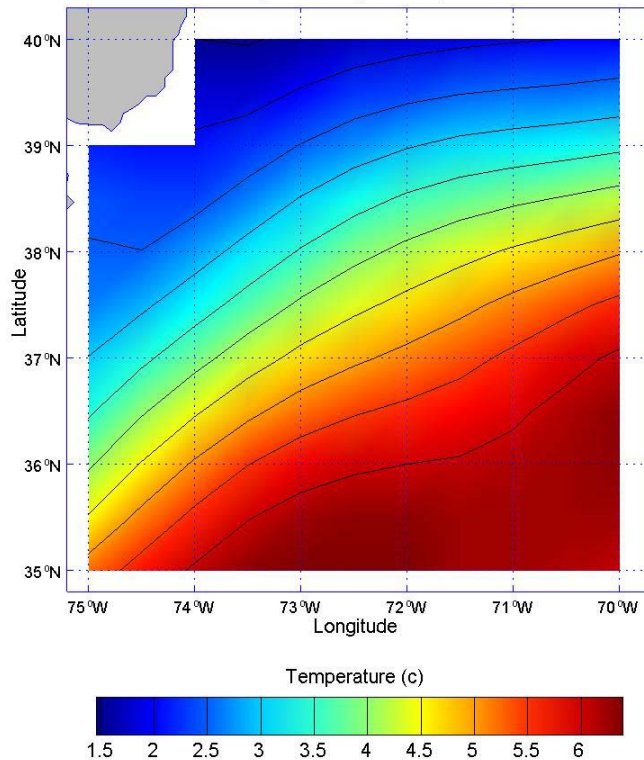# GDEM Surface View
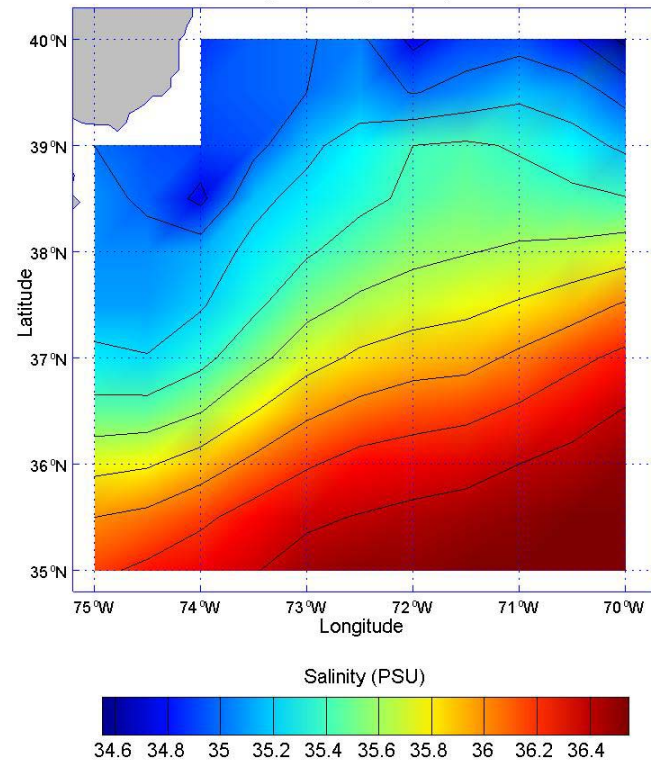
MODAS Surface View
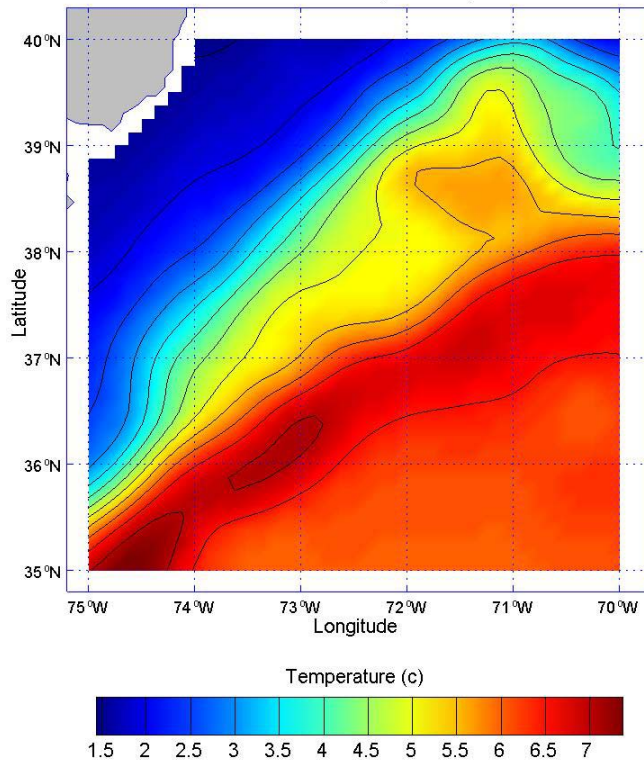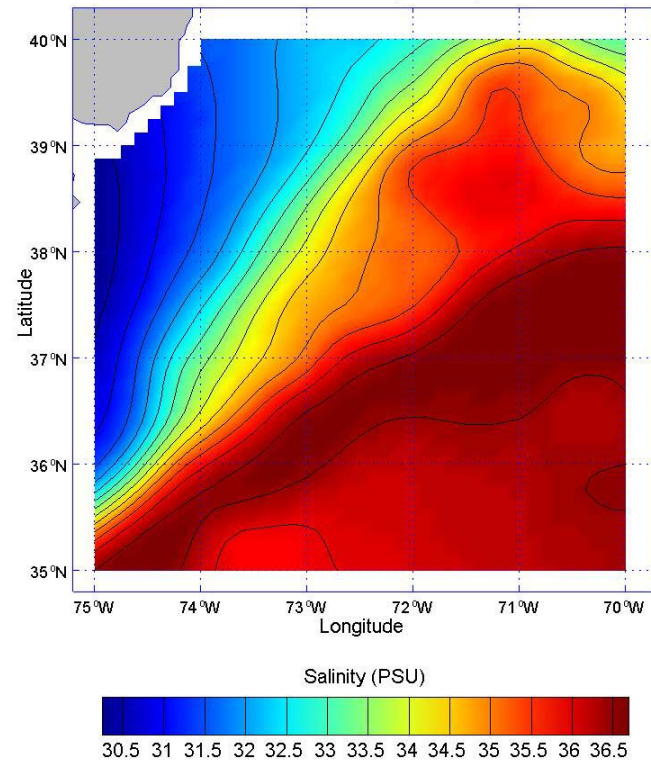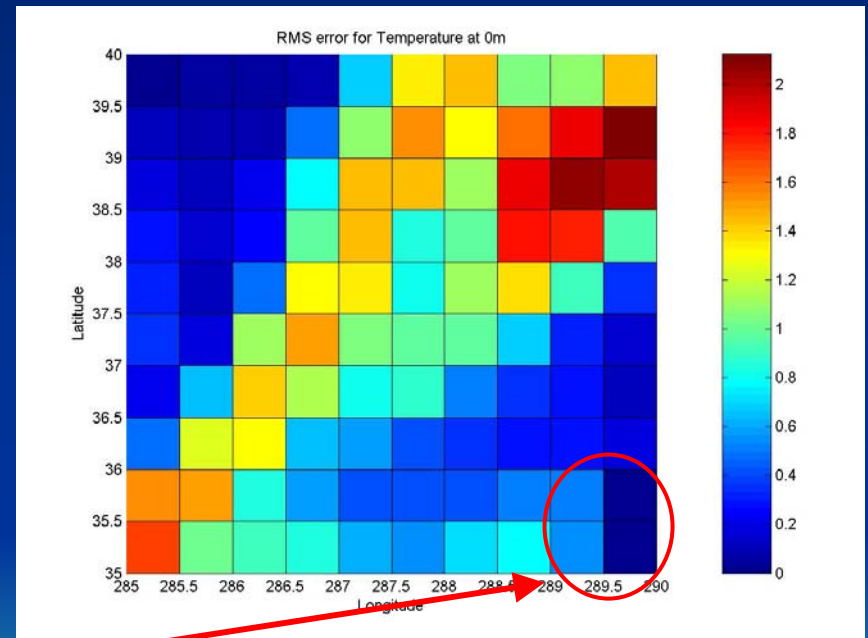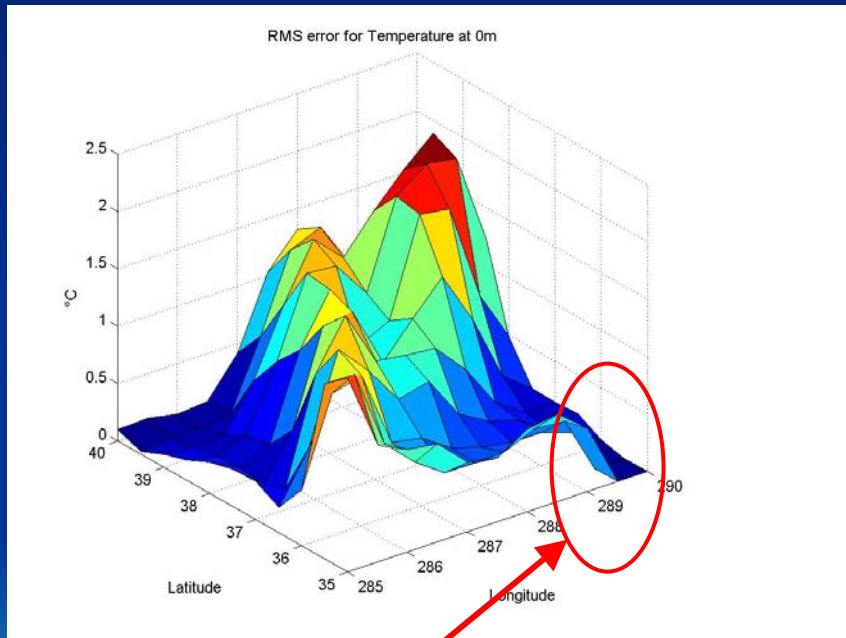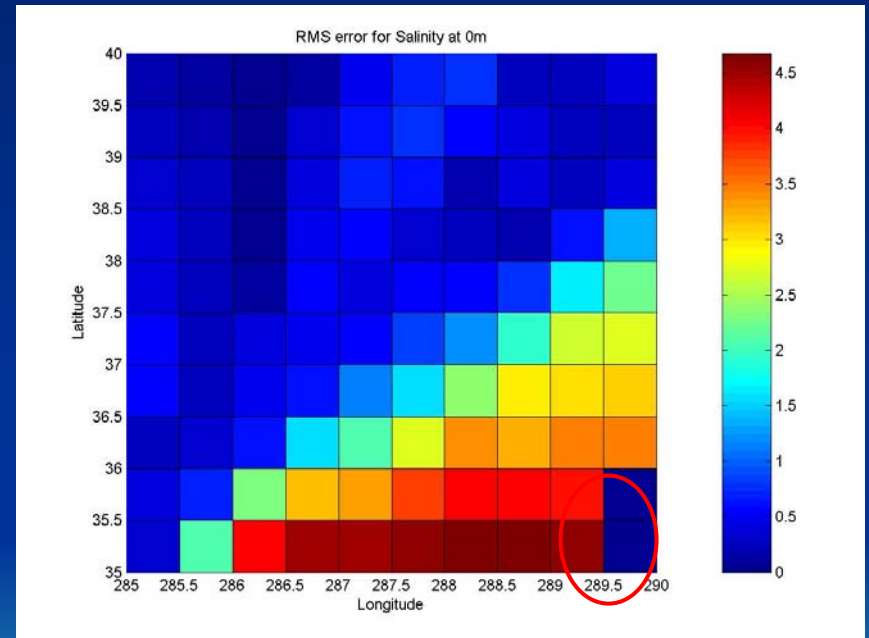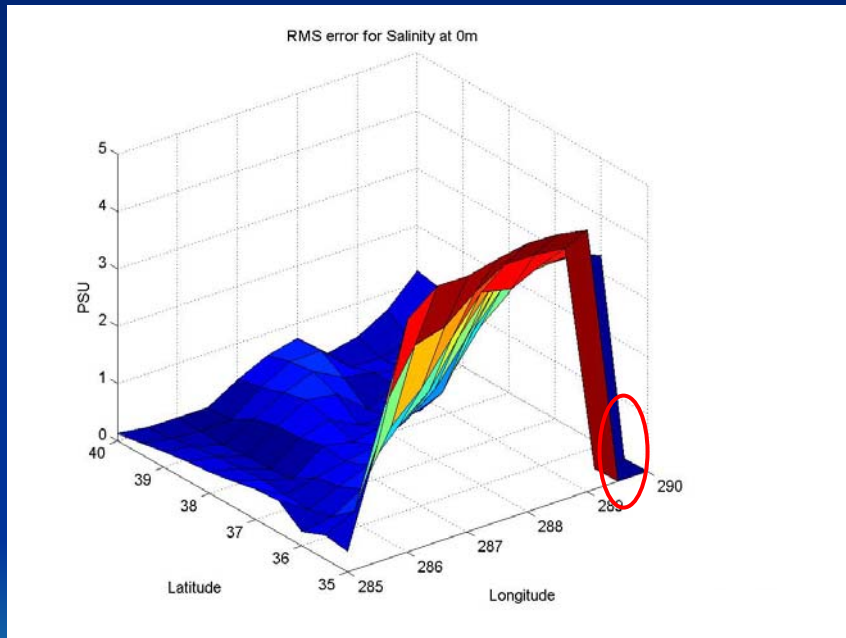
Surface

Surface

Surface
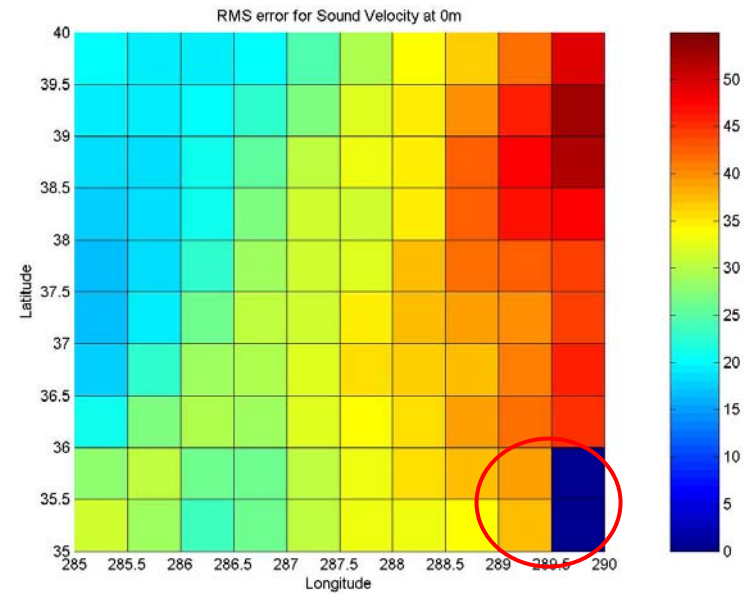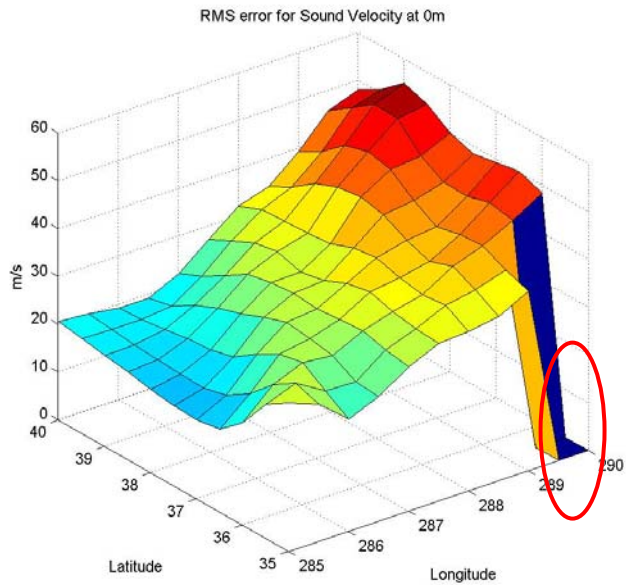
100m
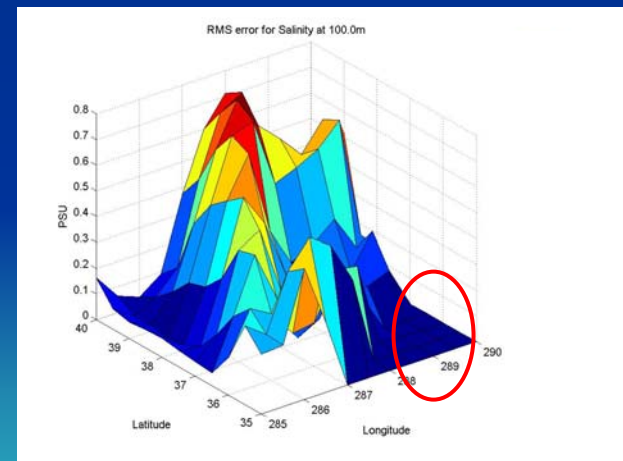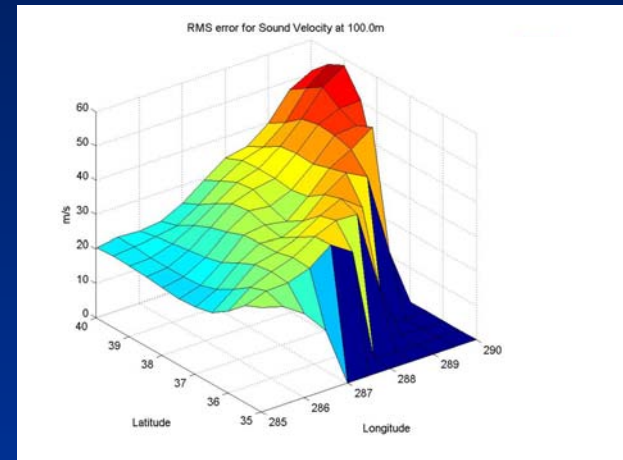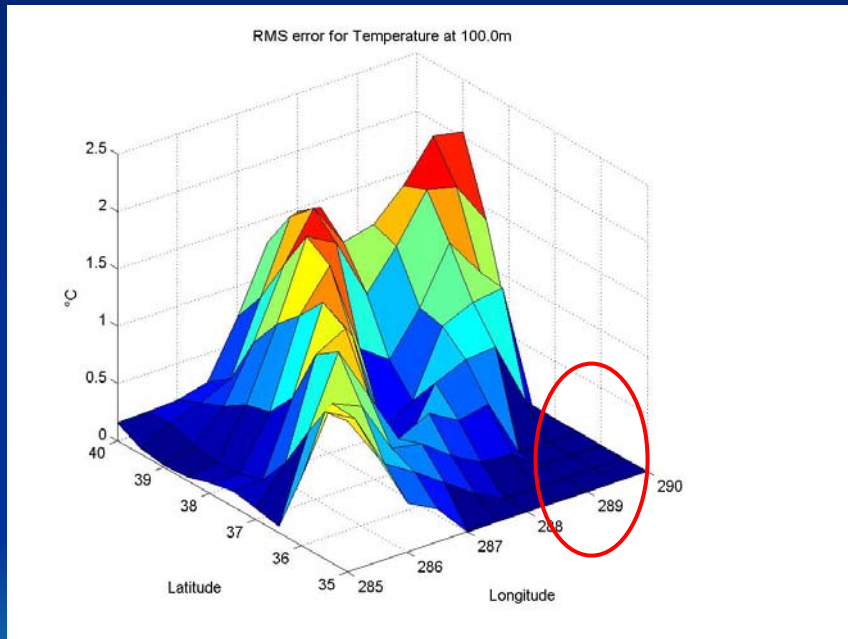
2000m
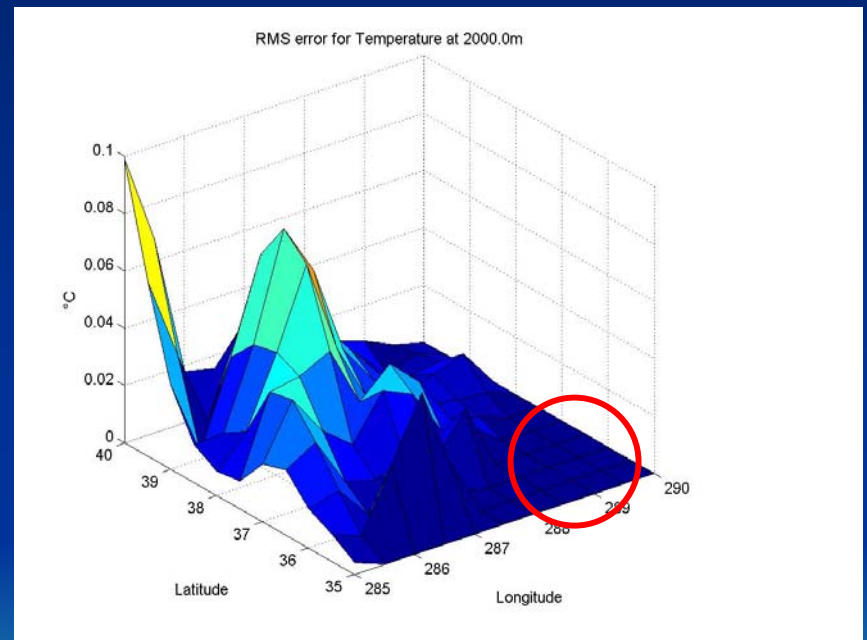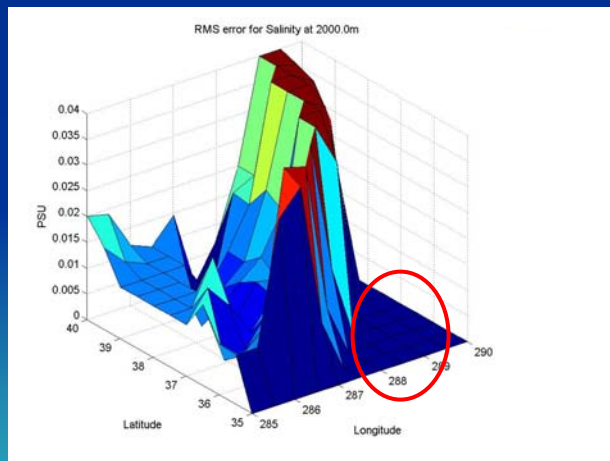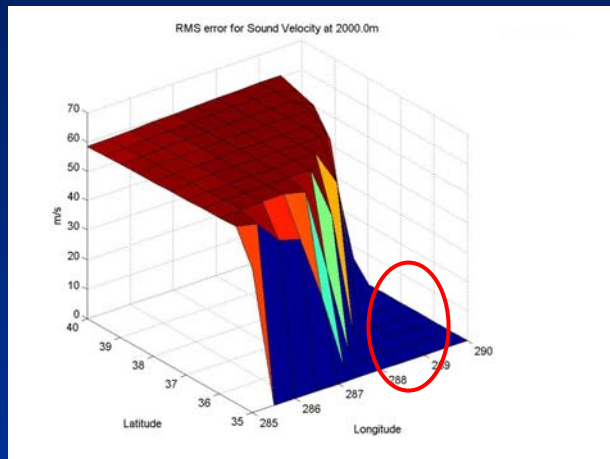
RMS Error Profiles
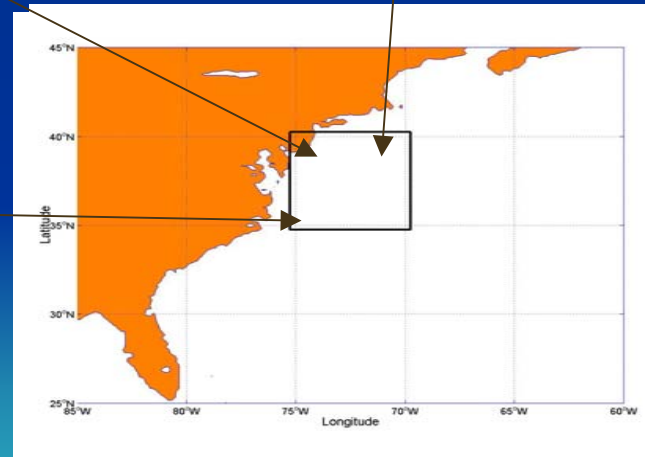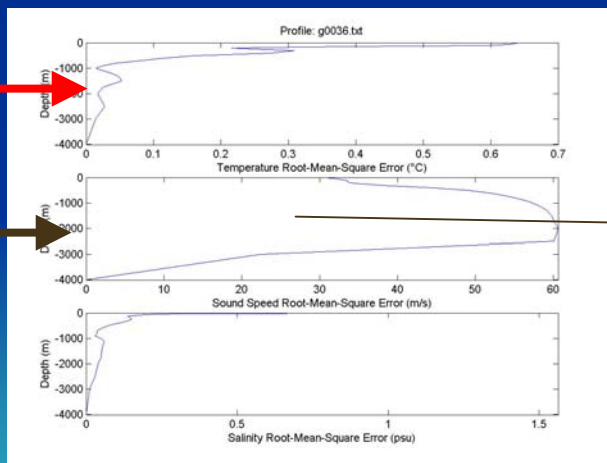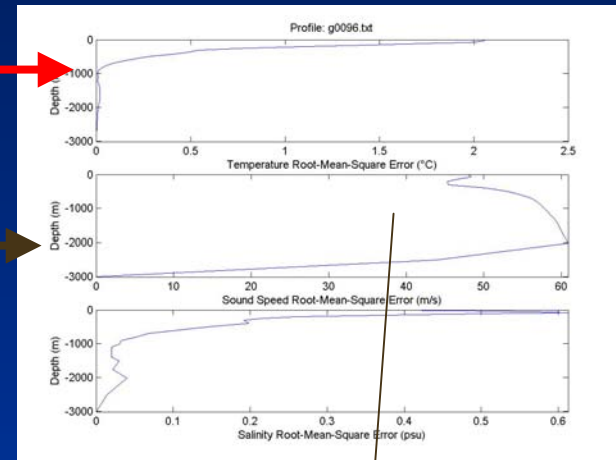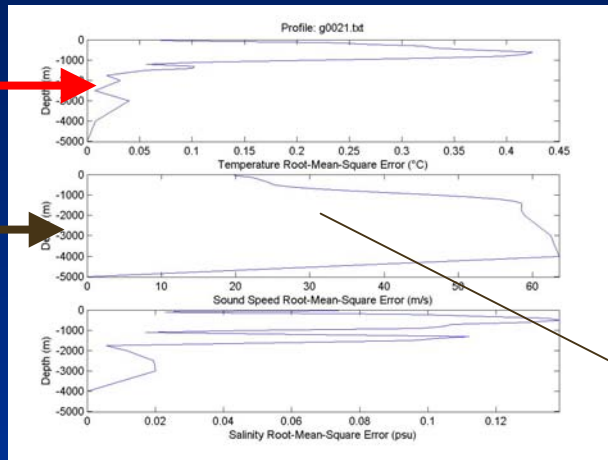
Processing

- Naval Undersea Warfare Center Division Newport
- Weapon Acoustic Preset Program (WAPP)
    - Mk48 Acoustic Preset Calculation
    - Output: Percentage Area Coverage

Development Efforts Background

- Torpedo Acoustic & Ballistic Preset Development Efforts Performed by NUWCDIVNPT, Combat Systems Department, Weapon Guidance and Control Branch (Code 2213)

- Additional Tactical Decision Aid and Modeling Development Efforts for Harpoon, Tomahawk, SLMM, ISLMM

- Points of Contact:
  - Gene Bessacini: bessaciniea@npt.nuwc.navy.mil
  - Dave Cwalina: cwalinads@npt.nuwc.navy.mil

Weapon's Acoustic Preset Program (WAPP) Objectives

- To Provide the Fleet with an On-Board Automated Interactive Means for Generating Mk 48 & Mk 48 ADCAP Acoustic Presets and Visualizing Torpedo Performance

- Base Computations on In Situ Environmental, Tactical, Target, and Weapon Parameters

- Track the Evolution of Weapon, Tactical, Target, and Environmental Models

- Provide Interfaces to

- Support Fleet Exercises, Training, and Program Deliveries

Acoustic Preset Program's

- Mk 48 Acoustic Preset Program (M48APP)—Mk 48 Mod 3/4
- Mk 48 ADCAP Acoustic Preset Program (MAAPP)—ADCAP Baseline, Shallow, TPU
- Weapon's Acoustic Preset Program (WAPP)—Integrated Mk 48 and Mk 48 ADCAP Capability
- Programs Provide a Presetting Capability Based Upon:
  - A Common Graphics User Interface for the Entry of Environmental, Tactical, Target, and Weapon Data
  - A Common Computational Engine for the Generation of Accurate Acoustic Performance Predictions
  - Common Output in the Form of a Ranked Listset of Search Depth/Pitch Angle/LD/Effectiveness Values Along With an Acoustic Ray Trace and Signal Excess Map
  - Mk 48 Mod Specific Presets/Vehicle Dynamics/Acoustics & Signal Processing

Program Evolution

- Initial Development of Mk 48 ADCAP Acoustic Preset Program to Support ADCAP Block I
- Incorporation of Shallow Water and Under Ice Capability
- Development of Mk 48 Mod 3/4 Presetting Capability
- Development of ADCAP Block II/Block IIA Capability
- Merge of
- High Frequency Environmental and Acoustic Sub-Model Update

Support Status

- Royal Australian Navy—Mk 48 Acoustic Preset Program Part of Collins Class Augmentation System (CCAS)
  - HP TAC-3/4 Host under Unix
  - Configuration Managed Under Product Version Control (PVC)
  - Application Embedded in Overall Architecture
  - Documentation and Training Provided
  - Provides Environmental Data Entry for CCAS
  - Interfaces to Other Tactical Systems Specified
- Royal Canadian Navy—Mk 48 Acoustic Preset Program Rearchitected for Java
  - PC version under development

File Changes Utilities   Help

Surface Conditions
Wind Speed (m/s):   2.57
Wave Height (m):   0.05
Sea State: 1
Rain: None
Shipping Level: None

Mode Messages

Bottom Conditions
SSP Depth (m):   1524.00
Bottom Type: Sand

Default Conditions
VSS Background (dB):   −75.00
Salinity: 35.00
Latitude: 45:00:00N
Longitude: 000:00:00E

Environmental Data

Velocity in Metres/Second
1463   1483   1503   1524

DEPTH IN METRES
0
121
243
365
487
609
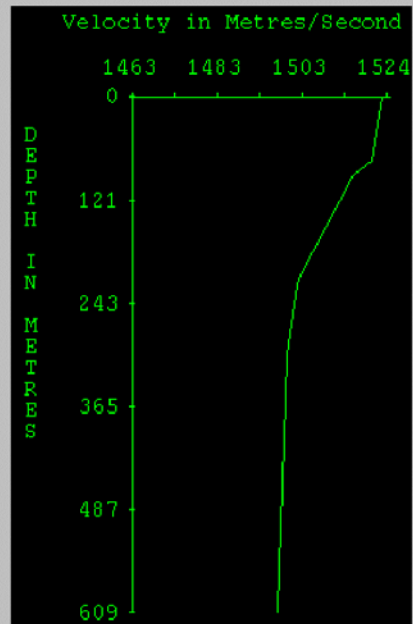
Profile : defalt
DTG:

Table Group Identifier
Surfaced Target   3
Submerged Target   3

Depth	Temp	Vel	VSS	Sal
0.0	20.44	1523.06	−75.00	35.00
76.2	19.06	1520.46	−75.00	35.00
91.4	17.50	1516.20	−75.00	35.00
213.4	12.67	1503.00	−75.00	35.00
243.8	12.22	1501.99	−75.00	35.00
304.8	11.44	1500.32	−75.00	35.00
1524.0	3.89	1491.84	−75.00	35.00

Environmental Data Entry (EDE) Module

- Graphic Interface for Entry & Examination of Sound Speed Profile(Depth, Temperature, Sound Speed, Volume Scattering, Salinity) and Entry of Sea Surface/Sea Bottom Conditions
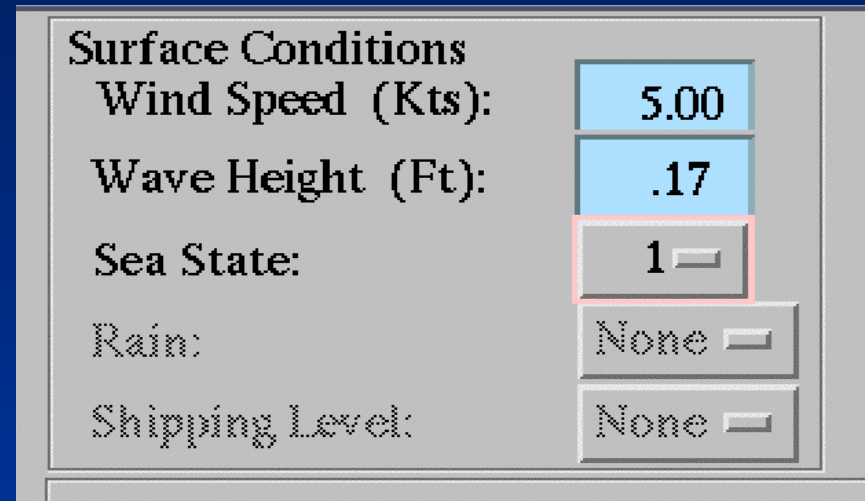
- Module Provides Manual Entry of Environmental Data for Op Area
  - US Systems Have Interface to Environmental Databases to Import System or Projected Environment
  - RAN Tactical Support System has Specification for Interface to Tactical Environment Sub-System (TESS) in Place

- Environmental Data is Associated to Preset Lists for Direct Recall of Computations

EDE
Sea Surface Conditions

- Wind Speed/Wave Height/Sea State Coupled for Entry of Any Value

- Coupled By World Meteorological (WMO) or Beaufort Scale Convention

- Supports Sea States (0-9 WMO, 0-12 Beaufort) & Ice Cover

Surface Conditions	
Wind Speed (Kts):	5.00
Wave Height (Ft):	.17
Sea State:	1
Rain:	None
Shipping Level:	None

WAPP
Environmental Data Entry (EDE) Module

- Sea Bottom Conditions
- Bottom Depth (Any Depth Shallower Than Last Point in Sound Speed Profile (SSP))
- Bottom Type
  - Mud/Sand (Lossy Bottoms)
  - Clay
  - Gravel
  - Rock

Bottom Conditions
SSP Depth (Ft): 5000.00
Bottom Type: Sand

EDE
Water Column Characteristics

- Water Column Characteristics
- Sound Speed Profile
  - Depth(ft/m)
  - Temperature(˚F/˚C)
  - Sound Speed(ft/sec, m/sec)
  - Volume Scattering Strength (VSS) (dB)
  - Salinity (ppt)
- Entry of Temperature or Sound Speed Supported With Computation of Unknown Quantity

Depth	Temp	Vel	VSS	Sal
.0	68.80	4996.90	-75.00	35.00
213.0	68.80	5000.40	-75.00	35.00
250.0	66.30	4988.40	-75.00	35.00
300.0	63.50	4974.40	-75.00	35.00
500.0	58.50	4949.80	-75.00	35.00
700.0	54.80	4931.10	-75.00	35.00
800.0	54.00	4927.80	-75.00	35.00
1000.0	52.60	4922.30	-75.00	35.00
1500.0	48.30	4902.50	-75.00	35.00

Velocity in Feet/Second
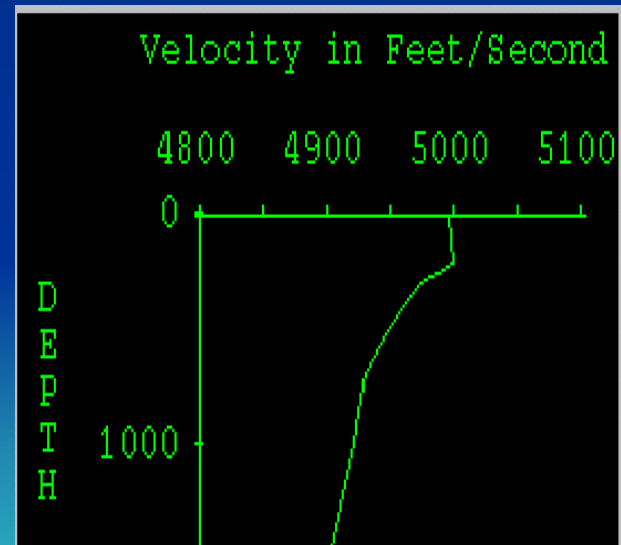
EDE
Additional Fields

- Profile Name: Character String
- Table Group Identifier Associated with Profile
- Default Volume Scattering Strength (dB)
- Default Salinity (ppt)
- Lat/Long

Profile : default

DTG:

Table Group Identifier
Surfaced Target   3
Submerged Target   3

Default Conditions
  VSS Background (dB):   –75.00
  Salinity: 35.00
  Latitude: 45:00:00N
  Longitude: 000:00:00E

Acoustic Preset Module Display

Acoustic Preset Module Preset Computation

- Compute Presets Selection Sets Weapon Default Presets Based Upon Tactical Guidance, Determines Valid Search Depth/Search Angle Selections, Ranks and Recommends Settings

- Rerank Allows for Deviation from Default Presets in the Computation of Presets

- Acquisition Allows User to Evaluate Any Allowable Preset Combination Via Ray Trace/Signal Excess Map

Compute	
Presets	Ctrl-P
Rerank	Ctrl-R
Acquisition	Ctrl-A

Acoustic Preset Module Tactical Presets

- Entry of Tactical Preset Values via Pull-Down Menus Configured for Mod 3/4

- Sub-Set of Total Tactical Presets Used in Acoustic Preset Computations

- Remaining Tactical Presets Entered to Complete Tactic List for Transfer to Combat Control System

Target Mode	Sub
Search Depth (m)	SD
Pitch Angle (deg)	PA
Ceiling (m)	10
Floor (m)	200
Doppler Enable	Out
Acoustic Search	Active
Trajectory Mode	Direct
Speed Combo	Hi/Med
Ping Interval	Long
Search Mode	Snake
Ash	In

Acoustic Preset Module Target Data

- Target Maximum Operating Depth Based on Target Classification

    - Limits Vertical Area Used in Acoustic Preset Computations

- Depth Zone of Interest (DZOI) Allows for Further Restriction of Target Region Based on Target Operating Characteristics

- Acoustic Target Strength (NTS dB)/Radiated Noise (NZE dBs)

- Anticipated Target Doppler (DIW, Low, High)

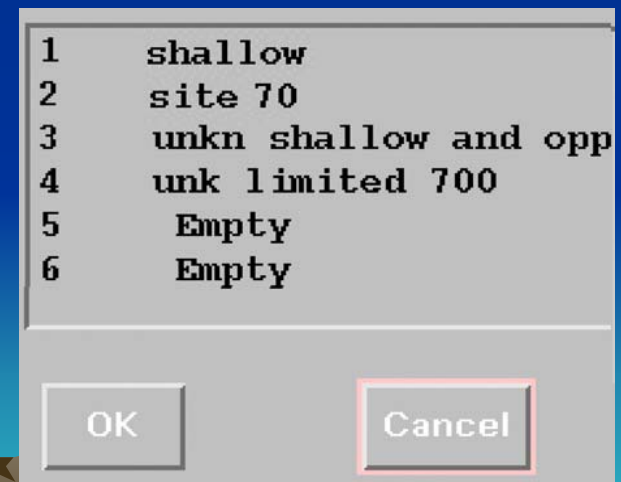|		
DZOI S/D (m)	0/ 213	...
NTS / NZE (dB)	10.0 / 85	...
Tgt Doppler (Spd)	High	
Tgt Max Depth (m)	213	

Acoustic Preset Module Ranked Listset

- List Set of Search Depth/Pitch Angle/Laminar Distance/Effectiveness Values

- List Set Ranked Based on Acoustic Coverage Effectiveness and Recommendation Made Accounting for Cavitation and Depth Separation

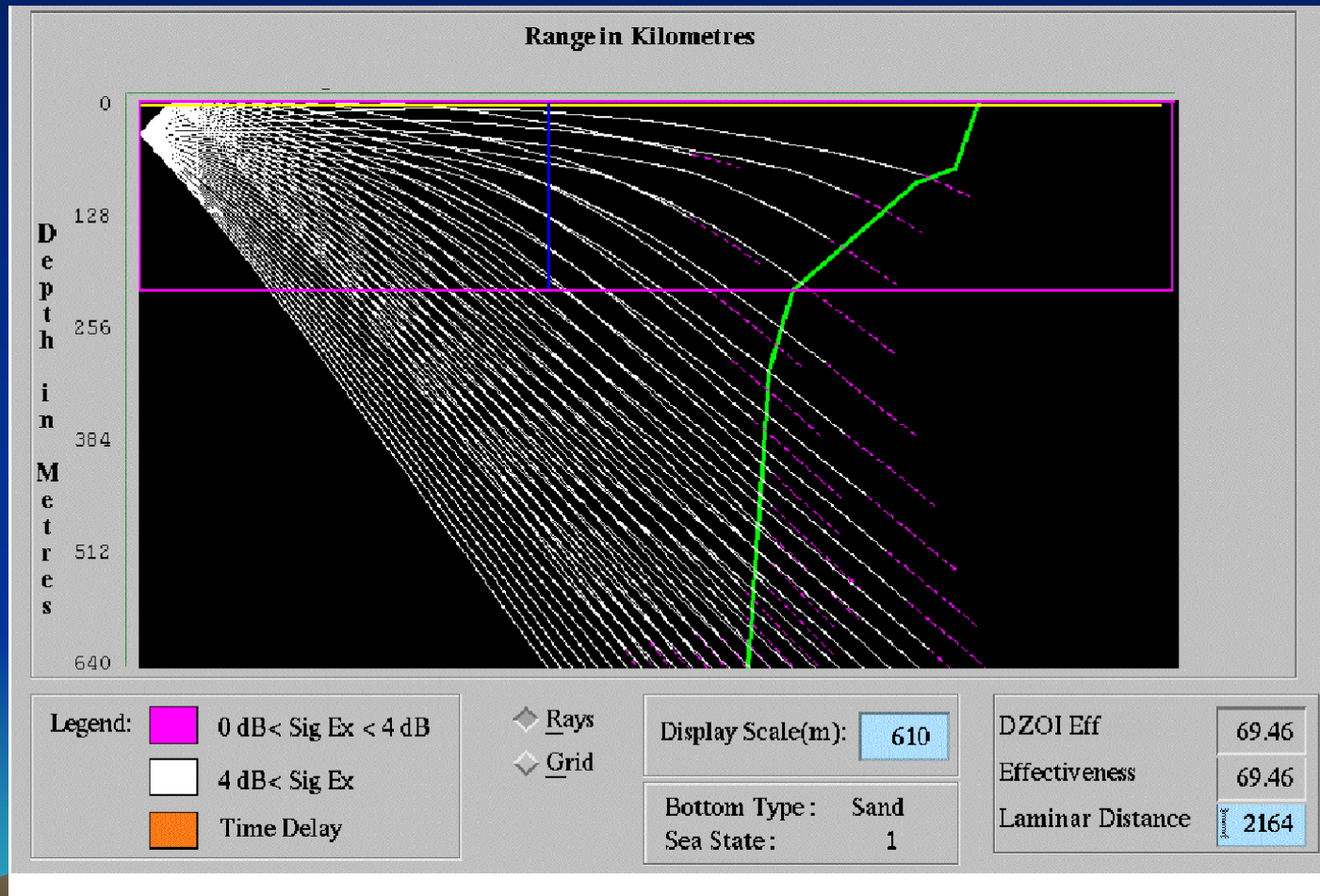- Laminar Distance Utilized in Weapon Order Generation for Gyro/RTE

SD	PA	LD	EFF
SD 1	PA 1	LD 1	EFF1
SD 2	PA 2	LD 2	EFF2
SD 3	PA 3	LD 3	EFF3
SD 4	PA 4	LD 4	EFF4
SD 5	PA 5	LD 5	EFF5
•	•	•	•
•	•	•	•
•	•	•	•

Acoustic Preset Module Tactic Lists

- Module Provides Capability to Store and Recall Tactical Preset Lists Along with Environmental Data, Scenario and Listset Data
- Data is Stored Local to Weapon's Module
- Lists May Be Transferred Via Network to Combat Control System
  - RAN Implementation Has Specification for Transfer to Engagement Sub-System (ESS)
 - Additional Window for Parameterization of Scenario/Environment for Transfer to Engagement Sub-System (ESS)

File
Store Tactic List
Recall Tactic List
Send Tactic List
Send Default Tactics
Clear Stored Tactics
Quit   Ctrl-Q

1   shallow
2   site 70
3   unkn shallow and opp
4   unk limited 700
5   Empty
6   Empty

OK   Cancel

Ray Trace Display

Acoustic Preset Module Ray Trace Display

- Ray Trace Selectable from Pull-Down Menu

- Provide a Visual Interpretation of Mk 48 Acoustic Performance

- Impact of Boundary Interactions and Refraction Shown

- Variable Target Depth Bands(Near-Surface, Depth Zone of Interest, Target Max Depth)

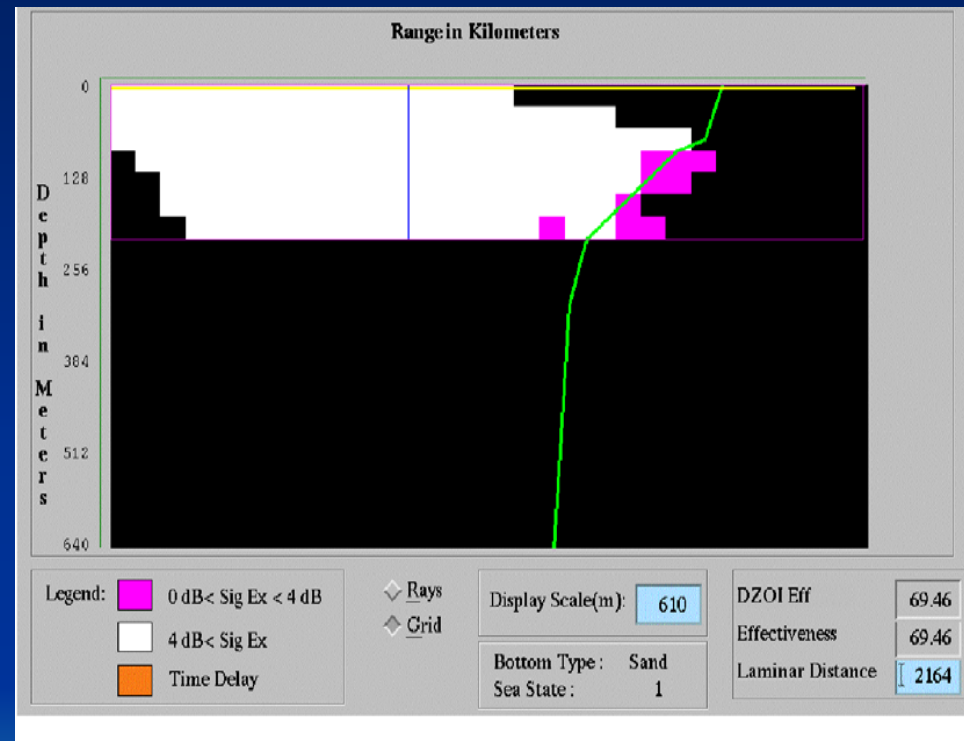- Effects of Reverberation Apparent for Low Doppler Targets
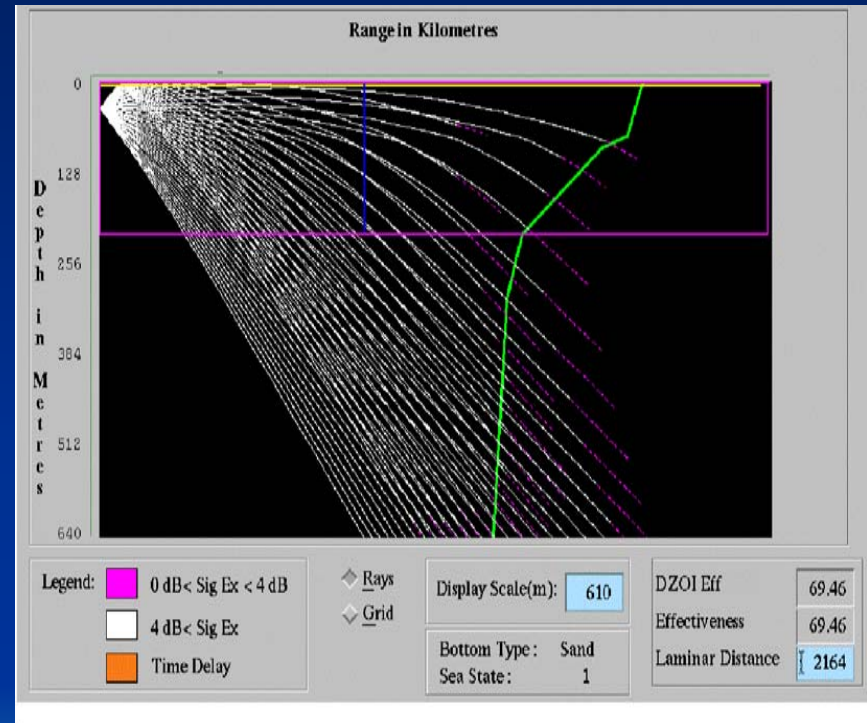
Signal Excess Display
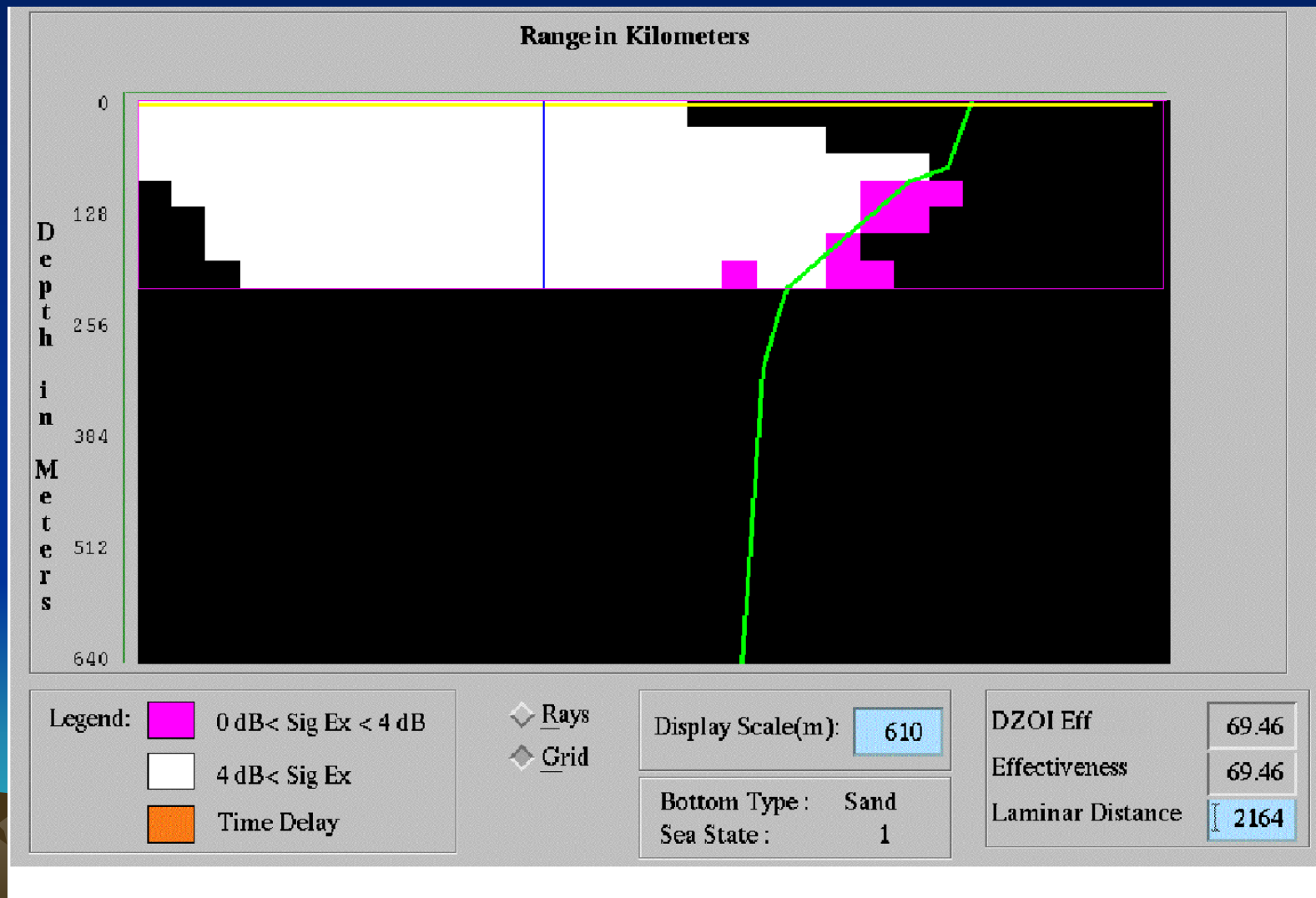
Acoustic Preset Module Signal Excess Display

- Signal Excess Selectable from Pull-Down Menu

- Provide a Visual Interpretation of Mk 48 Acoustic Performance Over Depth Band of Target

- Effects of Ray Bending Apparent

- Effects of Reverberation Apparent for Low Doppler Targets

Generated Output

- Percentage Area Coverage

- ASUW and ASW Scenarios

- Shallow, Mid, and Deep Search Bands

- Values Normalized Over Acoustic Modes

Shallow Depth ASUW Output

GDEM Coverage Area (Shallow Depth ASUW)
MODAS Coverage Area (Shallow Depth ASUW)
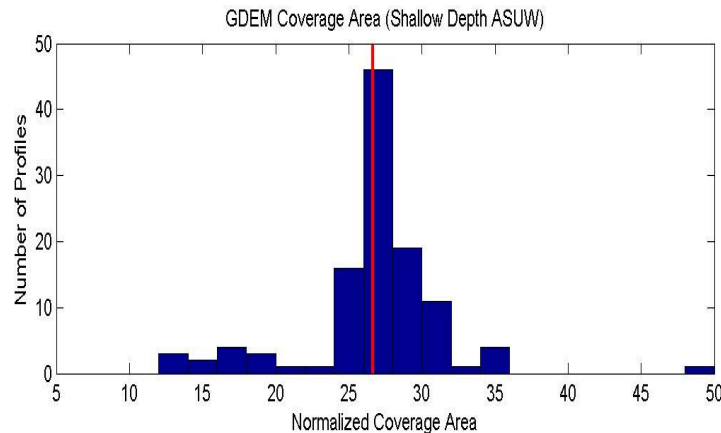
- MAX 48.9
- MIN 13.7
- MEAN 26.7
- STD 4.7
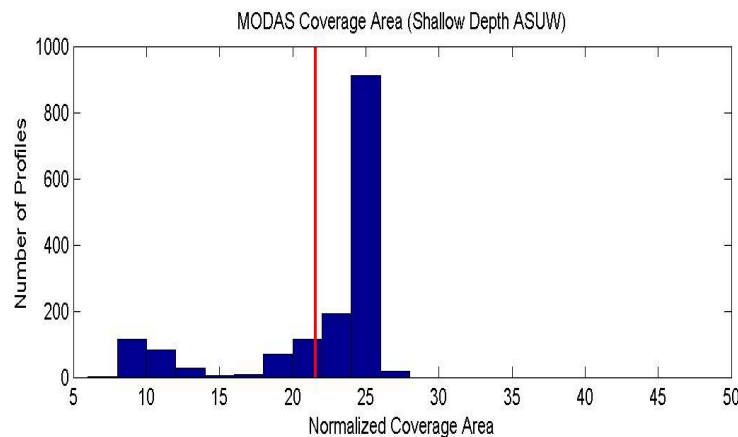
- MAX 26.2
- MIN 7.6
- MEAN 21.6
- STD 5.0

Shallow Depth ASW Output
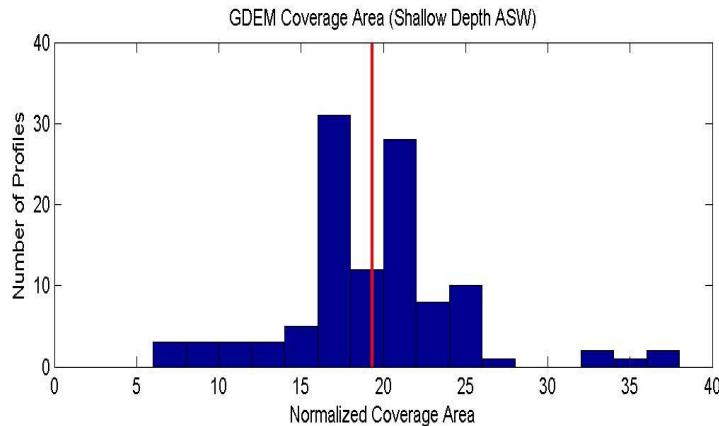
- MAX 37.4
- MIN 6.2
- MEAN 19.3
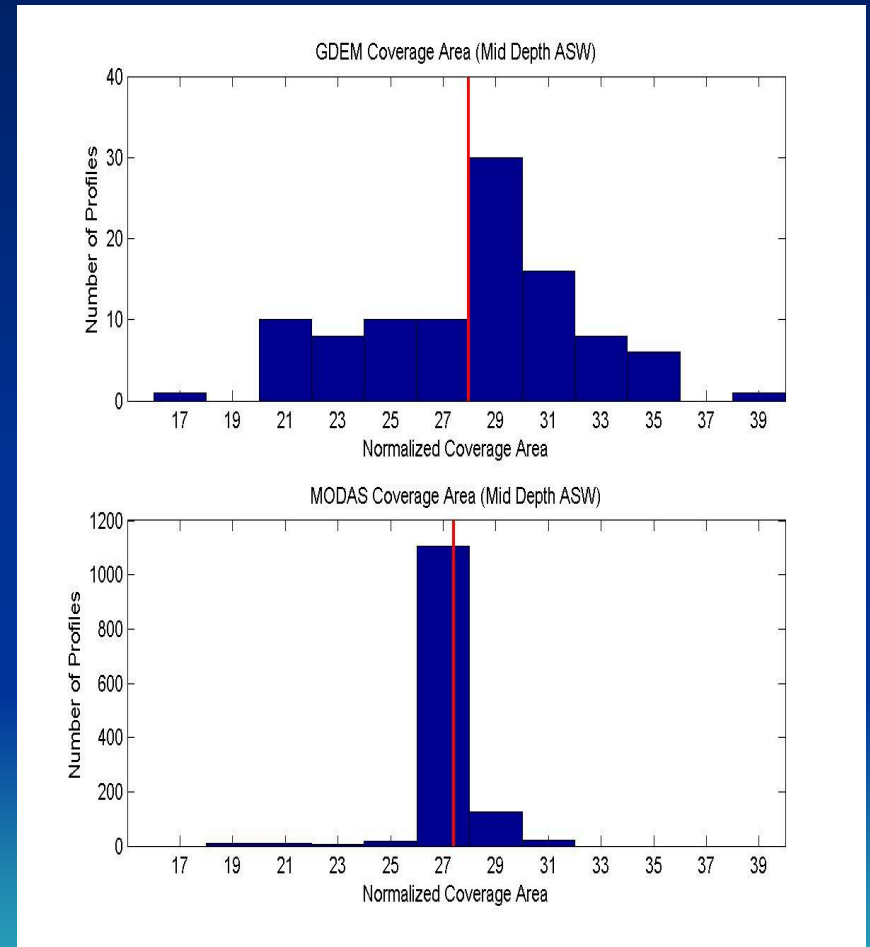- STD 5.2
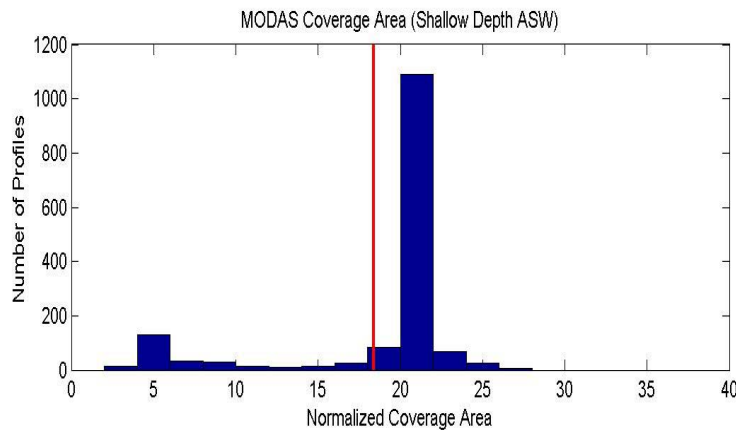
- MAX 26.1
- MIN 3.8
- MEAN 18.4
- STD 5.2

Mid Depth ASUW Output

- MAX 51.72
- MIN 18.6
- MEAN 34.2
- STD 5.0

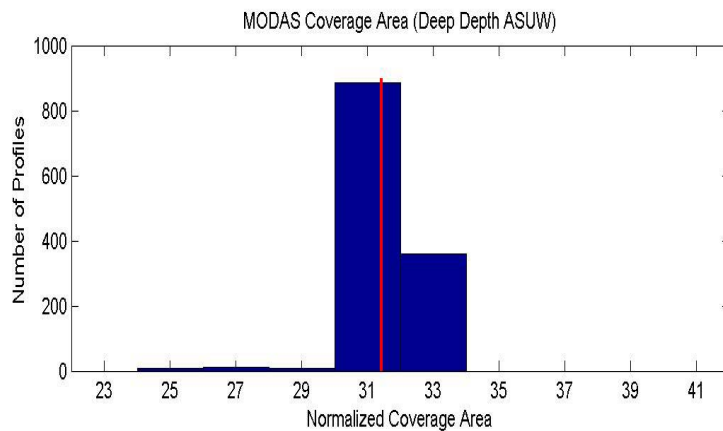- MAX 34.4
- MIN 0
- MEAN 31.7
- STD 4.0
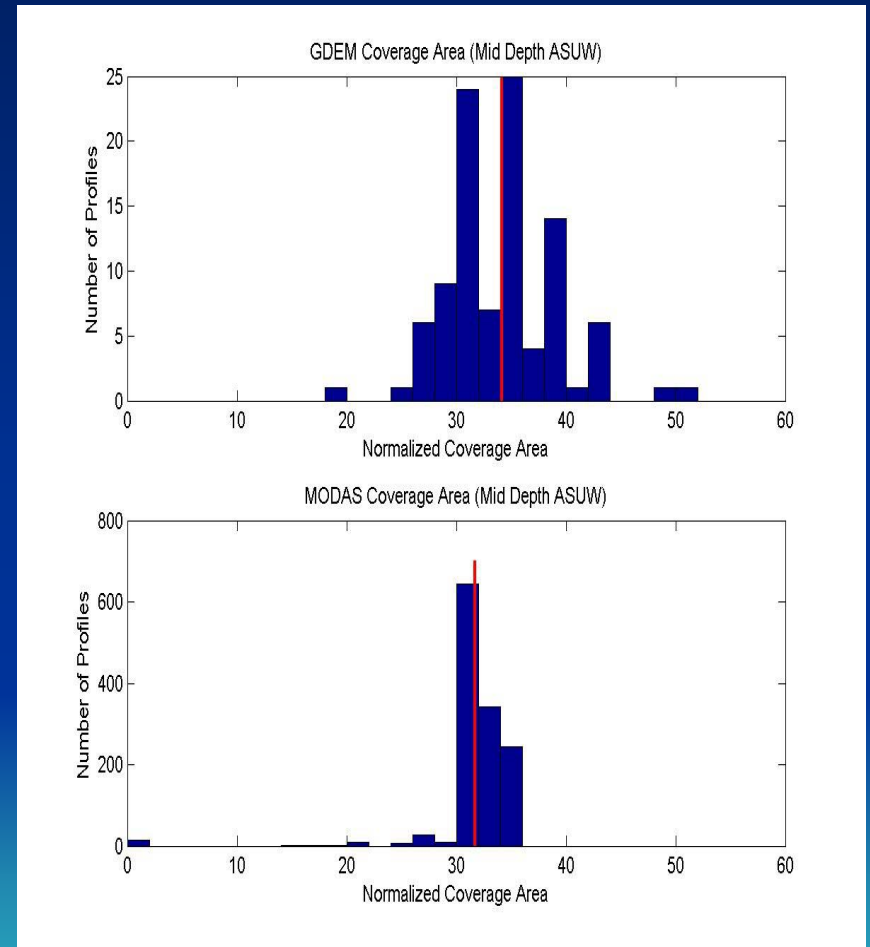
Mid Depth ASW Output

- MAX 38.9
- MIN 17.7
- MEAN 19.3
- STD 5.2

- MAX 30.6
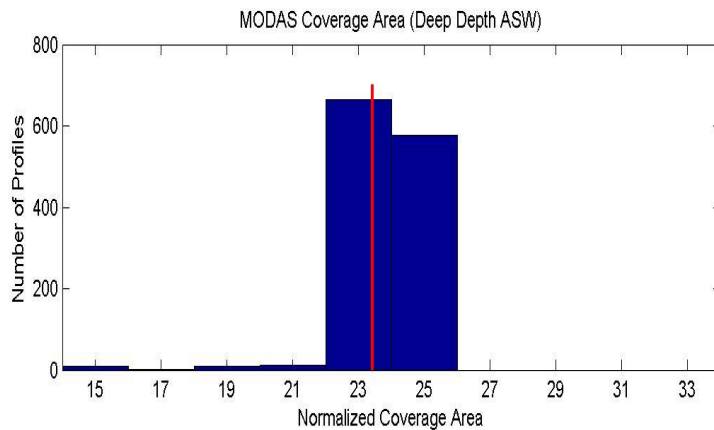- MIN 18.7
- MEAN 27.4
- STD 1.16

Deep Depth ASUW Output
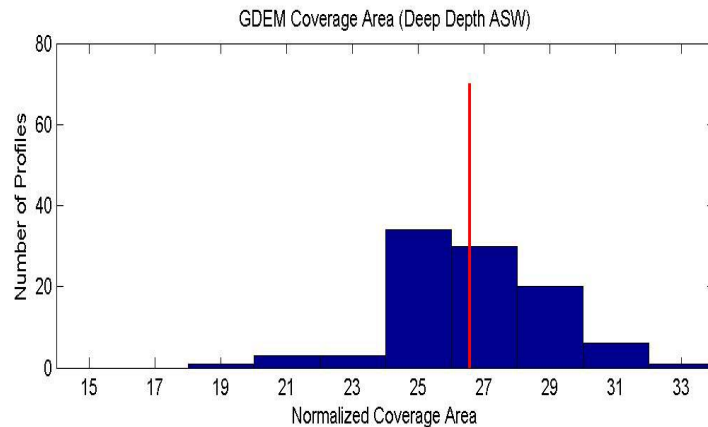

GDEM Coverage Area (Deep Depth ASUW)

MODAS Coverage Area (Deep Depth ASUW)
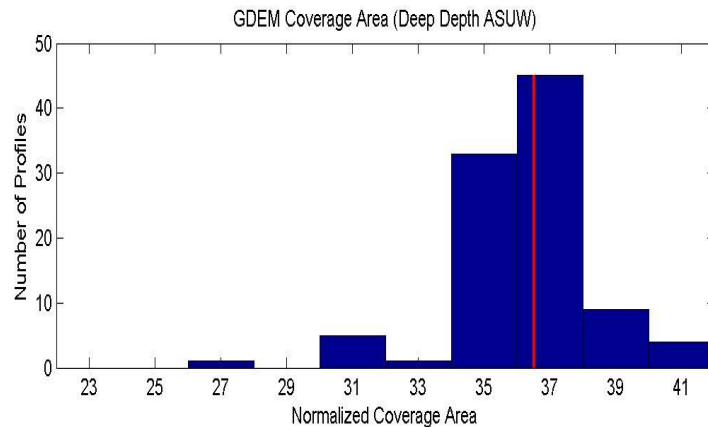
- MAX 41.4
- MIN 27.6
- MEAN 36.5
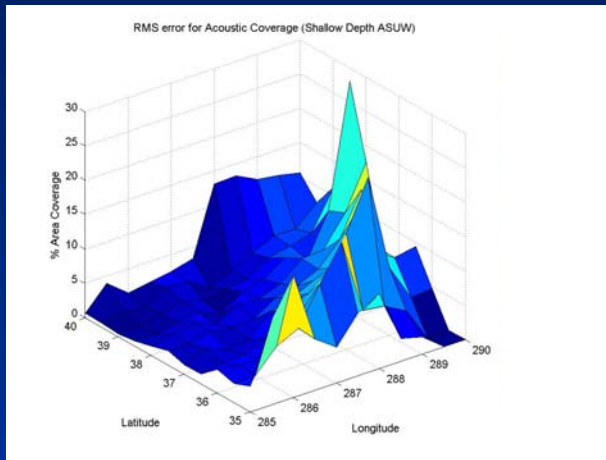- STD 2.4

- MAX 33.1
- MIN 24.1
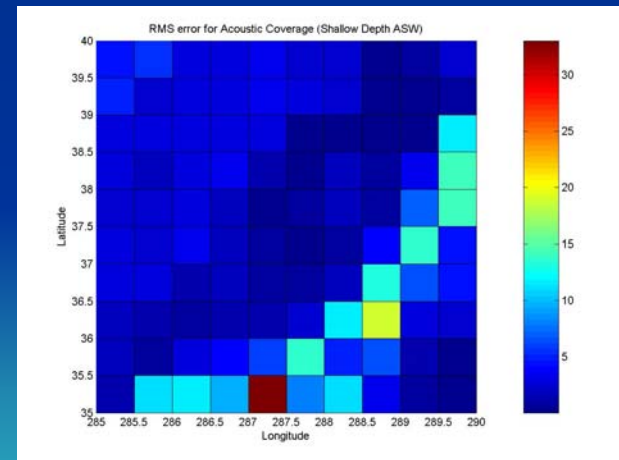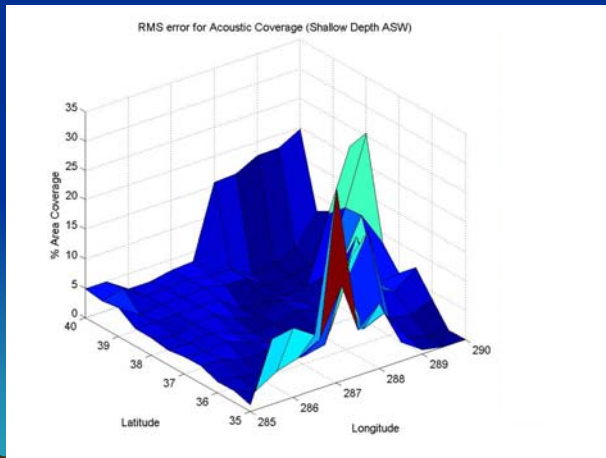- MEAN 31.4
- STD .9369

Deep Depth ASW Output

- MAX 32.0
- MIN 19.2
- MEAN 26.6
- STD 2.3

- MAX 25.1
- MIN 15.3
- MEAN 23.4
- STD 1.2

Shallow Depth Acoustic Coverage Comparison
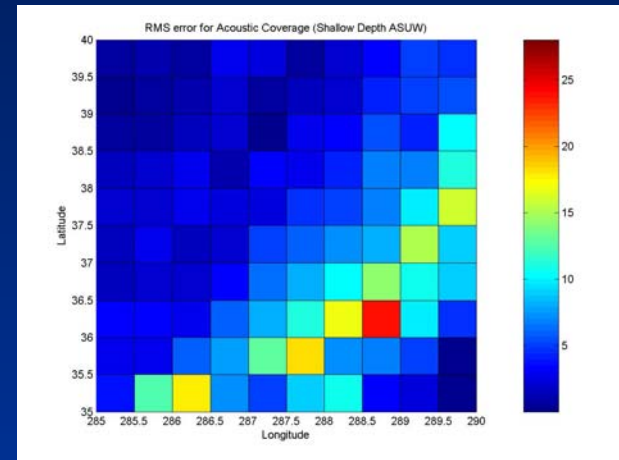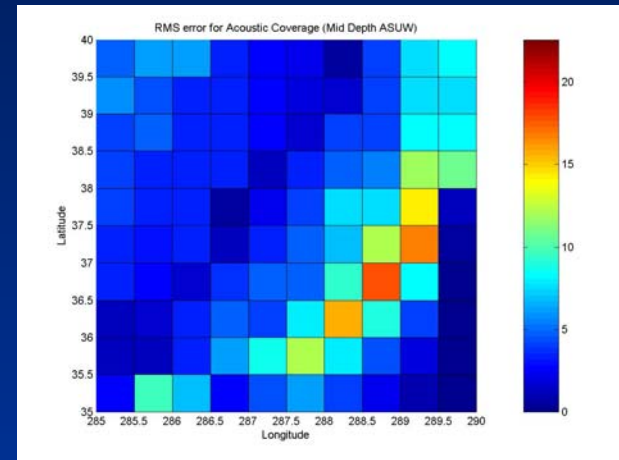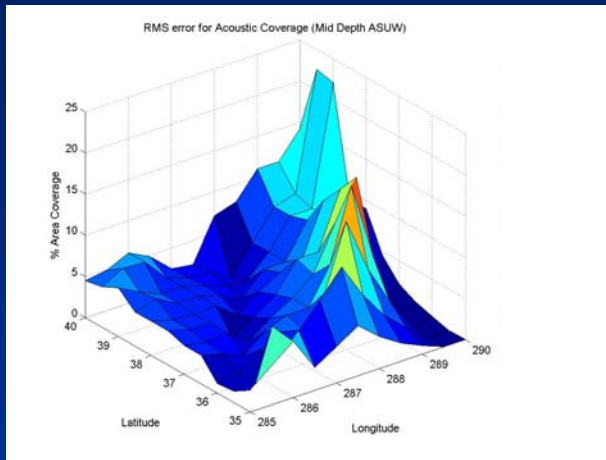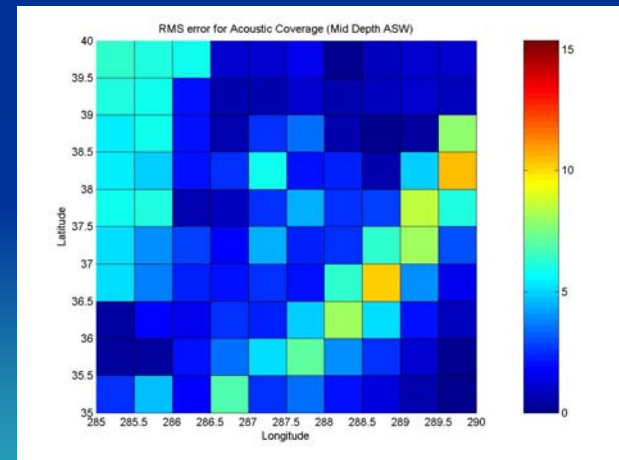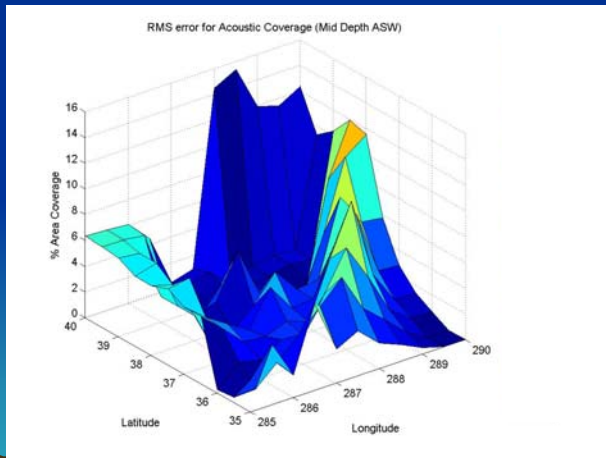
ASUW
SCENERIO

ASW
SCENERIO

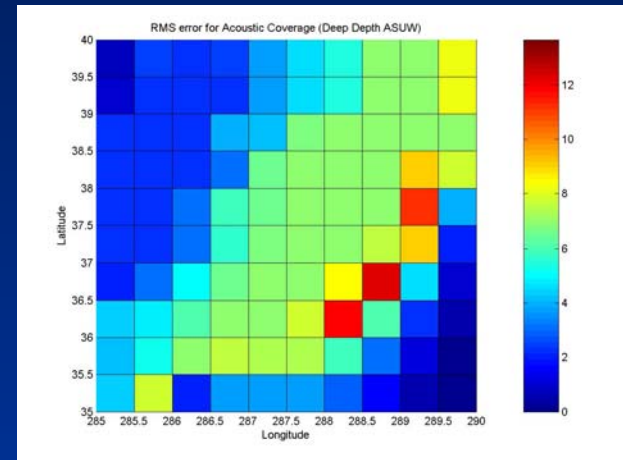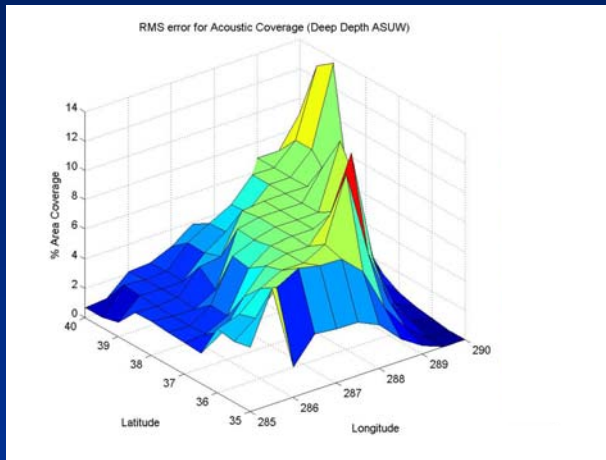# Mid Depth Acoustic Coverage Comparison

ASUW SCENERIO
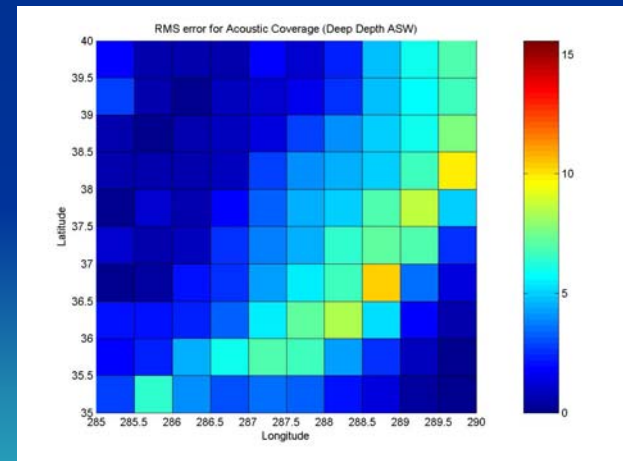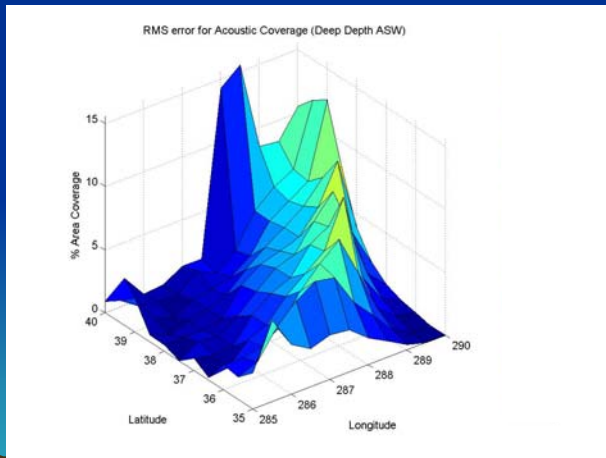
ASW SCENERIO

Deep Depth Acoustic Coverage Comparison

ASUW SCENERIO

ASW SCENERIO

Conclusions

- Percentage Area Coverage is an effective metric for comparing weapon presets
- MODAS offers reliable results over the whole area while GDEM is "hit or miss"
- MODAS initialized presets are optimized in Mid and Deep Depth Bands
- For Shallow Depth Bands MODAS and GDEM produced similar results

Future Projects

- More Extensive Data Set
  - Observe changes over time and for different locations
  - Examine areas of strong thermal or salinity contrast
- Altimeter Investigation
  - Vary the number of altimeters and observe the effect on area coverage
  - Determine optimal number of altimeters required

Sources

- http://128.160.23.42/gdemv/gdemv.html
  - GDEM information
- http://www7320.nrlssc.navy.mil/modas/
  - MODAS information
- Bennett, Theodore J., "Estimating the Rotation Rate of Mesoscale Ocean Rings from Satellite Altimetry," Naval Research Laboratory, Stennis Space Center, MS, NRL/FR/7322—93-9443, October 1993.
- Crout, R.L., "Radar Altimetry for Naval Applications," Presentation to the Standing Acquisition Coordination Team, 8 February 2000.
- Jacobs, Gregg A., Charlie N. Barron, Michael R. Carnes, Daniel N. Fox, Harley E. Hurlburt, Pavel Pistek, Roberts C. Rhodes, William J. Teague, "Navy Altimeter Data Requirements," Naval Research Laboratory, Stennis Space Center, MS, NRL/FR/7320—99-9696, November 1999.

Questions?